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UNITED STATES BUREAU OF MINES
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FELDSPAR

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BY

OLIVER BOWLES AND C. V. LEE

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

FELDSPAR[1]

By Oliver Bowles[2] and C. V. Lee[3]

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6381."

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INTRODUCTION

The mining and preparation of feldspar are attended by many complications; first because the material itself is variable in composition, second because it is associated with various types of impurities, and third because the requirements of different users and for different uses are subject to varying demands as regards composition, purity, and grain size. The producer would profit by a wider knowledge of the requirements of the consumer, and the consumer would gain a definite advantage if he understood more fully the nature and occurrence of feldspar, and were acquainted with the many difficulties surrounding the production of a ground product which will successfully meet the present varying requirements of analysis and fusion.

Through recent years, a systematic study of feldspar has progressed to a thoroughly scientific stage of research, until to-day no function of the industry is more important than the modern well-equipped testing laboratory which is finding a place in the plants of both producers and users. Through laboratory research, much is being learned of the properties of feldspar and of its behavior in use. There are obstacles still to be overcome, but those already surmounted have been of no less magnitude.

The Bureau of Mines has issued two fairly comprehensive reports on feldspar, Bulletin 53, "Mining and treatment of feldspar and kaolin in the Southern Appalachian region," and Bulletin 92, "Feldspar of the New England and Northern Appalachian States," both of them by A. S. Watts. The first was published in 1913 and the second in 1916, but both are now out of print. Although these reports contain much information of permanent value, they are now inadequate in some respects owing to the many changes that have taken place in the industry during recent years. The bureau receives many requests for information on feldspar, and the lack of published data has led to the preparation of this report.

It is not the purpose of this paper to present a comprehensive and detailed discussion of this complex subject, but rather to give a brief outline of the occurrence and properties of the material, its preparation, uses, and marketing, the economic problems of production and consumption, modern trends, and such other matters as are of interest to the average inquirer who desires a general knowledge of the industry.

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DEFINITION

Feldspar is not the name of a specific mineral; it is a general term in mineralogy for an important group of rockforming minerals consisting of several species, all of them anhydrous silicates of aluminum containing either potash, soda, or lime, or two of these bases together. These varieties are divided into two groups, the potash feldspars and the lime-soda feldspars. Orthoclase and microcline are the chief representatives of the first group, while albite and oligoclase are the most important of the second or plagioclase group.

VARIETIES AND CLASSIFICATION

The most common potash feldspars are orthoclase and microcline, both of them having the composition $KAlSi_3O_8$ and differing only in their form of crystallization. Anorthoclase or soda-microcline is a feldspar in which the potash is replaced in part by soda, and hyalophane is a feldspar in which part of the potash is replaced by barium. The soda-lime feldspars or plagioclases comprise an isomorphous group, the extremes of which are albite or soda spar ($NaAlSi_3O_8$) and anorthite or lime spar ($CaAl_2Si_2O_8$). Between these two extremes there may be any number of varieties containing soda and lime in varying proportions. Oligoclase, andesine, and labradorite are names applied to certain of these intermediate varieties. Clevelandite is a lamellar variety of albite. Barium feldspar, known as celsian ($BaAl_2Si_2O_8$) is of rare occurrence.

Orthoclase and microcline are the most important feldspars of commerce and are of common occurrence. Albite is the most important of the plagioclase group; it is used much less extensively than the potash feldspars. Perthite is a laminated feldspar consisting of plagioclase and orthoclase or microcline in alternating bands. When the laminations are so fine that they are recognizable only with a microscope, the rock is known as microperthite.

Orthoclase and microcline are identical in composition, consisting in pure form of 16.9 per cent K_2O, 18.4 per cent Al_2O_3, and 64.7 per cent SiO_2. Commercial potash feldspars may vary considerably from the theoretical composition. Small percentages of iron, lime, and soda are usually present. Albite or soda feldspar if free from impurities contains theoretically 11.8 per cent Na_2O, 19.5 per cent Al_2O_3, and 68.7 per cant SiO_2. However, due to the isomorphous nature of the plagioclases, lime may be present in an albite up to a proportion of 1 part of lime to 6 parts of soda.

PHYSICAL PROPERTIES

The physical properties of all varieties of feldspars are remarkably similar. Microcline has a specific gravity of 2.5, a hardness of 6 to 6.5 according to Moh's scale of hardness, and crystallizes in the triclinic system. Its color is generally white, grayish yellow, yellow, or any shade of red from light rose to brick, the red color being commonly attributed to the presence of finely divided iron oxide or hydroxide. "Amazonstone" is a green variety of microcline which is used for ornamental purposes.

Orthoclase has a hardness of 6, the same specific gravity as microcline, and has the same range of colors except green. It crystallizes in the monoclinic system.

Albite has a specific gravity of 2.6, ranges in hardness from 6 to 6.5 and crystallizes in triclinic form. Its color is generally white, although it may be reddish, greenish, bluish or gray. Anorthite has a specific gravity of 2.8 and a hardness of 6 to 6.5.

Potash feldspar has three directions of cleavage, intersecting at definite angles. Only two of the cleavages are well defined, and these invariably intersect at right angles in orthoclase and almost at right angles (89° 31') in microcline. Both of these principal cleavage surfaces show a high luster, comparable to that exhibited by a plate of glass, though one cleavage face is a trifle less brilliant than the other. The two lustrous cleavage planes intersecting at an angle of approximately 90° are usually sufficient to identify the mineral as potash spar.

Soda feldspar in its commonest form also shows two lustrous cleavage faces which intersect at about 86°. The difference in angle between the cleavage faces of the potash and the lime-soda feldspars is not readily recognizable without careful measurement. Albite and other lime-soda feldspars may often be distinguished from potash feldspars by the presence of faint straight striations on the cleavage faces. By turning the crystal slightly one way or another the striations are readily recognized. The cleavage of feldspar facilitates crushing and grinding and makes it easy to reduce the crystalline masses to angular particles.

ORIGIN AND OCCURRENCE

Feldspar bearing rocks are of igneous origin - that is, they have solidified from molten masses. Feldspars are regarded as originating in granites and related rocks, which generally occur as vast intruded masses, and consist essentially of quartz, feldspars, and mica or hornblende.

The feldspars in granite occur in grains varying in size from that of a pinhead to one-half inch or more across. Such small crystals associated with other minerals can not be regarded as profitable sources of supply even though in total quantity they constitute a vast amount of material. It is a remarkable fact, therefore, that while feldspar is the most abundant mineral in the world, the difficulty of separating it from the impurities associated with it in granites and related rocks is so great that such occurrences under present conditions must remain unutilized, and commercial supplies must be sought in those restricted occurrences where nature has made the desired separation.

The feldspar of commerce is obtained from pegmatite dikes. Pegmatites are generally regarded as representing the final stage of consolidation of granite masses. The molten material, consisting chiefly of the elements which combine to form feldspar and quartz, also contained water vapor and numerous volatile elements and gases such as fluorine, chlorine, boron, phosphorus, and sulphur. These so-called mineralizing agents tended to maintain a condition of fluidity in the mass, which was forced by great pressure into fractures or lines of weakness in the rocks already solidified. The effect of the mineralizers was to promote coarse crystallization, and when solidification finally took place, the irregular fissure-filling dikes consisted chiefly of large masses of feldspar and quartz, single crystals being 1 foot or even several feet thick. The residual molten material with associated gases and vapors combined in various other ways and crystallized out, forming in addition to quartz and feldspar a series of characteristic pegmatite minerals such as muscovite, biotite, tourmaline, garnet, and beryl.

When the pegmatite crystallization is exceptionally coarse or the constituents of the dike are separated into distinct bands, it is sometimes possible to obtain feldspar in commercial quantity practically free from associated minerals. In most dikes, however, the feldspar and quartz are crystallized too intimately to permit complete separation. Quartz is by far the most abundant mineral associated with feldspar, but its presence in moderate amounts is not harmful, as silica in the form of quartz or flint is an essential constituent in most of the batches in which feldspar is used. However, it is important to know how much quartz is present in order that proper allowance may be made in calculating the batch composition.

Muscovite, or white mica, also is almost always present, but as it ordinarily occurs only in subordinate amounts it is not particularly objectionable except that, being in thin, flexible plates, it does not readily grind to the required fineness. Other impurities such as tourmaline, garnet, and beryl are usually present in amounts of less than 1 per cent.

Feldspars of different types may be associated in the same dikes. Thus it is evident that commercial deposits of pure feldspar having constant composition are of rare occurrence.

Pegmatites may be in the form of fairly well-defined dikes that persist at depth, or may occur as lens-like pockets of quite limited extent. They may be found in the parent granite mass or in schists, slates, or other rocks that overlie or are adjacent to an occurrence of massive granite.

WEATHERING EFFECTS

Feldspar exposures are affected more or less by atmospheric agencies. In the Southern States weathering effects have been noted to depths of 60 to 80 feet. The effects are principally of two kinds: First, an alteration of the feldspar itself, which when carried to completion changes it into sericite, kaolin, or both; and second, the staining and impregnating of the feldspar with iron oxide, clay, earthy materials and other deleterious impurities as the result of infiltration of surface water. Feldspars are the principal minerals from which kaolin deposits are formed.

USES

The principal use of feldspar is as a flux in the manufacture of glass, pottery, enamel ware, brick, and tile. It is a constituent of both body and glaze. Feldspar, which constitutes from 10 to 35 per cent of the body, is used to bind the particles together. The amount of feldspar used in the glaze ranges from 30 to 50 per cent. Various forms of opaque glass that find use in hotels, restaurants, drug stores, and other places where a vitrified surface is desired for sanitary reasons, contain considerable quantities of feldspar. Bath tubs and wash bowls are commonly made of cast iron, and while hot are covered with an enamel containing much feldspar. It is also an important constituent of electrical and other forms of porcelain. Exceptionally pure potash feldspar is used in the manufacture of artificial teeth.

The use of feldspar in the glass industry is increasing, as it provides a readily soluble source of alumina. Potash feldspar is widely used, though mixtures of soda and potash spar are also sold to glass manufacturers; it is also employed with fluorspar in the manufacture of opalescent glass. Feldspar provides both alumina and the alkalies in the manufacture of bottle and pressed glass products. When a definite combination of alumina, potash, and silica (as in feldspar) is used, the constituents are assimilated more readily in the melt than if introduced separately. Recently a glass bottle plant as Oshawa, Ont., has been designed to use feldspar as practically the sole raw material. It is claimed that feldspar increases the lustre and toughness of glass. It permits a longer working temperature in the machine, thereby permitting a greater production of bottles per hour for any given equipment. It also tends to retard the weathering or what is known as the bloom of glass in storage.

Up to the present time feldspar has found limited use in the window and plate glass industries, though some manufacturers are finding it advantageous. Its general acceptance would increase the demand for feldspar enormously.

Very clean feldspar is used as a constituent of scouring soaps and window-cleaning compounds. It is preferred to quartz abrasives for cleaning glass and enamel ware because it is somewhat softer than quartz and is less likely to scratch the surface.

Feldspar is used as a binder in the manufacture of emery and corundum wheels. For this use it may be fairly high in silica, but the specifications are rigid in regard to other impurities and to uniformity in grinding.

The more impure grades of feldspar find use in the manufacture of certain floor coverings and as a constituent of roofing material, sand paper, paint, wood filler, and terra cotta. Ground feldspar is also used as a flue-dust arrester.

Crushed spar is used in considerable quantities in the form of granules for surfacing prepared roofing, in concrete work, in stucco and pebble dash, in Faïence work, and in the facing of cement blocks, particularly those designed to resemble granite. It is used as aand-blast material and as a poultry grit. Crushed spar graded in several sizes is sold for foundry facings.

Potash feldspar has at times been used in Portland cement manufacture to increase the potash yield, where potash recovery was practiced. Ground feldspar is of value as a fertilizer only under exceptional conditions, because the potash is in a form too insoluble for plant assimilation. Experiments in the extraction of potash from feldspar continue, but no commercially practicable means of recovery have yet been found.

The following table indicates the approximate percentage of feldspar consumed in the United States for the various uses.

Approximate consumption of feldspar in the United States by uses

	Per cent
Ceramic and glass industries	87
Scouring soaps and abrasives	7
Binder for abrasive wheels	2
Poultry grit, roofing, stucco and other minor uses	4

According to figures submitted by one operator, the 87 per cent used in the ceramic and glass industries may be subdivided by use as follows:

	Per cent
Glass	30
General ceramic ware	15
Electric porcelain	13
Tile	11
Sanitary ware	9
Enamel	9
Total	87

SPECIFICATIONS AND TESTS

Feldspar to be used in the pottery and glass industries should burn to a uniform white color and be free from specks or spots. It must be free from iron-bearing minerals such as biotite, garnet, hornblende and black tourmaline, and have little or no mica. For the finer grades of pottery the quartz limit is about 5 per cent, for ordinary pottery the quartz may run as high as 15 to 20 per cent. For glass making a spar of high alumina content is preferred. Dental spar is carefully selected white potash feldspar. For scouring soap the feldspar should be quartz free. For roofing, cement-block surfacing, and chicken grit more impure grades of spar may be used.

The terms No. 1, No. 2, and No. 3 spar, sometimes used in market reports, have only a general meaning, No. 1 being a selected grade of the product of the district, No. 2 a grade less carefully selected than No. 1 and generally higher in quartz and muscovite, and No. 3 a grade containing more impurities than No. 2. Neither No. 1 nor No. 2 grade may contain biotite (black mica) garnet, or tourmaline in amount sufficient to affect noticeably the color of the feldspar when fused. In some districts a No. 1 grade will carry no free silica, though in other districts the same grade will carry 10 or even 15 per cent quartz.

Manufacturers of clay wares demand an exceptionally finely pulverized product, usually not more than 1 per cent residue remaining on a 200-mesh sieve, though coarser grades are used at times. The glass and enameled metal industries use coarser material. The ordinary requirement is 20 mesh for glass and 100 mesh for enamel, but occasional orders are received for 40, 60, 80, and 140 mesh for both of these applications.

Until recently, feldspar has been bought and sold on rather loose and indefinite specifications. As a result of the misunderstanding and confusion that have attended the buying and selling of ground feldspar, a committee was appointed by the Division of Trade Standards of the Bureau of Standards at the request of the Feldspar Grinders' Institute to recommend a standard for feldspar. The difficulty in arriving at exact specifications is due in large measure to lack of a definite classification of feldspars. As a step toward the establishment of better specifications, a tentative standard classification of feldspars was established through two conferences of producers, distributors, users, and technical advisors, the first meeting being held at the Bureau of Standards in Washington, D. C., on January 14, 1930, and the second in Toronto, Canada, on February 18, 1930. The text of the recommended classifications as sent out for the approval of the industry is in four sections.

Section I states that "This commercial standard classification covers ground feldspar used in the production of ceramic products, based on particle size and chemical composition. It is to be regarded as a classification rather than a definite purchase specification."

Section II states that all screen tests shall be made on screens of the United States standard sieve series, and Section III contains the following table of acceptable screening analyses.

Table 1.- Acceptable screening analyses[1]

U. S. standard sieve series, number	Amount remaining on No. 200 sieve, per cent	Maximum percentage on sieve, designated	U. S. standard sieve series, opening in In.
230	0.00- 0.35	1.0	.0024
200	0.35- 1.00	1.0	.0029
170	1.00- 2.50	1.0	.0035
140	2.50- 5.00	1.0	.0041
120	5.00- 9.00	1.0	.0049
100	9.00-14.00	1.0	.0059
80	14.00-21.00	1.0	.0070
60	21.00-30.00	0.6	.0098
40	30.00-42.00	0.3	.0165
20	42.00-62.00	None	.0331

[1] This fineness classification shall be made on a basis of the percentage remaining on the standard 200 sieve and that remaining on the sieve designated. Example: 140 sieve product will have 2.5 to 5.0 per cent remaining on the 200 sieve and less than 1 per cent on the 140 sieve.

Section III includes also the chemical classification, based upon composition as it influences use, and describes three groups.

The first group includes the commonly accepted ceramic or body grades based on silica content and alkali ratio, and containing less than 4 per cent soda (Na_2O) content. The numbers designated are for the purpose of illustration, and additions may be made to the various groups up or down the scale to provide for all commercial grades of feldspar. The silica number and ratio numbers are to be used in combination. For example: Grade No. 67-51 designates a spar of silica content 66.00 up to 67.99 per cent, and with 5 to 6 parts of potash (K_2O) to 1 part of soda (Na_2O).

Number	Silica (SiO_2) Content
65	64.00-65.99 per cent
67	66.00-67.99 per cent
69	68.00-69.99 per cent
71	70.00-71.99 per cent
73	72.00-73.99 per cent

Number	Potash (K_2O) - Soda (Na_2O) Ratio
61	6 or more potash to 1 soda.
51	5 potash to 1 soda up to 6 potash to 1 soda.
41	More than 3 and less than 5 potash to 1 soda.
31	3 or less potash to 1 soda.

The second group includes the spars used chiefly for glazing purposes, which are based on soda content and contain 4 per cent or more soda (Na_2O).

Number	Soda (Na_2O) Content
4	4.00-4.99 per cent
5	5.00-5.99 per cent
6	6.00-6.99 per cent
7	7.00-7.99 per cent
8	8.00-8.99 per cent

The third group includes the spars used in glass-making and are based on silica, alumina, and iron content. The numbers are to be used in combination. For example, grade 69-17-X represents a grade of spar of 68.00 to 69.99 per cent silica, 17.00 to 17.99 per cent alumina, with a maximum of 0.15 per cent Fe_2O_3 content.

Number	Silica (SiO_2) Content
65	64.00-65.99 per cent
67	66.00-67.99 per cent
69	68.00-69.99 per cent
71	70.00-71.99 per cent

Number	Alumina (Al_2O_3) Content
15	15.00-15.99 per cent
16	16.00-16.99 per cent
17	17.00-17.99 per cent
18	18.00-18.99 per cent
19	19.00-19.99 per cent

Number	Iron (Fe_2O_3) Content
X	A maximum of 0.15 per cent
XX	A maximum of 0.20 per cent
XXX	Above 0.20 per cent

Section 4 covers the details of physical tests and chemical analyses.

It was decided that following receipt of a satisfactory majority of acceptances, the commercial standard classification would be effective three months after announcement of the success of the project. A large majority of the groups most directly interested, comprising the grinders, distributors, and consumers of feldspar, has expressed approval of this commercial standard, and September 1, 1930, was set as the date on which the standard would be effective for new production.

MINING

Feldspar is mined by open-pit and also by underground methods. Feldspar deposits vary greatly in physical character and in chemical analysis, and large scale production of uniform grades of material is not easy. Unless exceptionally well located or of unusual purity, deposits less than 25 feet wide can not be worked advantageously at depth, though many surface deposits of small size are worked to advantage. Usually mining conditions are so complex that operation on a large scale should not be undertaken without the help and advice of a trained geologist or mining engineer with practical experience in commercial production of feldspar.

The overburden on the dike is removed by hand, drag scraper, hydraulic, or other methods, depending on local conditions. The removal of the rock itself is accomplished by drilling and blasting. Pneumatic drills are generally used. Because feldspar and quartz are both very hard minerals, drilling is expensive. Picks, shovels, crowbars and similar tools are employed in handling the feldspar and waste. Forks are generally used in loading.

In North Carolina about half the feldspar production is from large well-equipped open-cut quarries or underground mines, and half from small surface deposits that are worked sporadically by contract. The life of a feldspar mine is not particularly long, rarely exceeding 10 years. The small surface deposits are of even shorter life; therefore the provision of continuous supply demands the discovery and development of new deposits, of which there seems to be an almost unlimited number.

The cost of mining is quite variable as it depends largely on the percentage of marketable feldspar recovered. If the feldspar, quartz, and mica have a tendency to be segregated in large clean masses the mining cost is low, because sorting is simplified. However, it is claimed that in many of the mines only 1 ton of marketable feldspar is recovered for every 5 tons of rock mined, and in many of the surface deposits the proportion of marketable spar to waste may be as low as one to seven. One of the most expensive steps in mining, under such circumstances, is the hand-cobbing of crude feldspar to free it of impurities. Crushers and picking belts have been installed at some mines to eliminate the high cost of hand-cobbing.

Nearly all of the mica of commerce is obtained from pegmatites; thus masses of mica may be associated with the feldspar. If mica of good quality is found in paying quantities it may constitute a valuable by-product. The associated crystalline quartz may also find a market for some of the various uses to which silica is applied, but the price of silica is so low that profitable utilization can be found for very little of it. Certain of the more rare and semiprecious minerals, such as beryl and tourmaline, are sometimes found in commercial quantities.

MILLING

Feldspar for all purposes must either be crushed or ground. A tendency has been noted to establish mills near the mines, though some of the important grinding mills are located at consuming or marketing centers and others are situated at an intermediate point where a milling-in-transit rate may be obtained.

Until recently, feldspar was sledged to about 2-inch size and crushed by an edge runner or chaser mill consisting of two burrstones or granite wheels 3 to 5 feet in diameter and 1 foot or more thick, traveling in a circle, the spar being crushed between them and a stone bed. The coarser material was returned to the edge-runner, and the fine material was passed to pebble mills consisting of cylinders 6 or 7 feet long containing flint pebbles which ground the spar as the cylinders revolved. The material was ground for a fixed period of time or for a given number of revolutions which experience had proved to be sufficient for the fineness desired. Thereafter the mill was emptied and a new charge added. This "batch" system has been replaced by the continuous type of grinding in many mills.

Sledging methods and edge-runners were employed to avoid iron contamination, but it has been found that the wear on manganese steel jaw crushers is too slight to cause any difficulty through the addition of iron impurity. Jaw crushers are now used in many mills.

Modern feldspar grinding mills vary somewhat in equipment and method, but the following is a typical layout of the more efficient mills now in operation.

The crude feldspar is transported to the mills in box cars, automobile trucks, caterpillar tractors, wagons, narrow-gage trams or aerial tramways, the method depending greatly on the distance the material must be transported. It may be unloaded directly into the crusher or it may be dumped into a storage bin or pile and later conveyed to the crusher.

The spar delivered to the mill is usually graded as to its composition, and the various types are segregated in separate bins. Having made many chemical analyses and careful observations of the spar analyzed, operators become skilled in judging quality. The chemical composition of the spar is commonly estimated to within 1 per cent of its actual silica or alumina content merely by visual examination. Spar arriving from many sources, such as the numerous surface deposits in North Carolina, may be graded into 30 or 40 bins.

The present tendency to prepare a spar of high purity and uniformity demands such machinery as screens, rotary washers, picking belts, and magnetic pulleys to extract all objectionable material as nearly as possible.

The handling of the material and the equipment employed in the larger mills is outlined in the following paragraphs. The spar as it comes from the mines may be segregated by variety and placed in a series of storage bins, or it may be passed through a primary crusher before reaching the bins. Primary crushers are usually of the jaw type, and commonly reduce the spar to 2-inch size. When material of uniform and known composition is stored in separate bins it is possible to draw it off in calculated proportions that will satisfy any reasonable specifications. Belt conveyors equipped with poidometers may be provided to facilitate accurate proportioning. At other mills the proper proportions are attained by taking a definite number of wheelbarrow loads from each of several bins.

The product of the primary crusher may all be passed through the secondary crusher for reduction to minus ½-inch size, though in some mills an intermediate screen is provided to separate the finer materials in order that they may by-pass the crusher. The product of the secondary crusher passes to a dryer usually of the rotary type. Careful drying is essential for efficient pulverizing. The spar is stored after drying, and further blending is accomplished as it passes from the storage bins to the grinding mills. Automatic samplers are provided.

Most of the fine grinding is now done in silica-lined pebble mills, using flint pebbles as grinding media. As the mill rotates, the cascading of the pebbles grinds the spar to a fine dust. Air-swept tube mills are employed in some plants. A continuous air current removes the material as soon as it reaches a sufficient degree of fineness to be carried away.

Sizing is usually accomplished with air separators, the rejected coarser particles being returned to the tube mill in closed circuit. The air separator may be regulated for any desired degree of fineness.

In the simpler types of mills, crushing is accomplished in a single stage and no samplers or intermediate storage bins are provided. From crude storage bins in which the spar is segregated by variety the material passes to a jaw crusher and through a dryer, or goes direct to pebble mills in closed circuit with screens or air separators. The final product is stored or is passed directly to railroad cars.

The ground product is conveyed to freight cars or to storage bins. A novel conveying method involves the use of compressed air, which carries the pulverized spar through iron pipes about 4 inches in diameter to the various storage bins.

Dust collecting systems are being used in some plants. They improve working conditions in the mills, prevent dust nuisances in surrounding territory, and conserve fine material which would otherwise be wasted.

GRINDING CAPACITY

The grinding capacity of the feldspar mills in the United States in 1929 has been estimated at approximately 480,000 long tons, while total sales in 1929 reached about 210,000 long tons. Present demands for feldspar, therefore, utilize only about 44 per cent of grinding plant capacity.

MARKETING

Feldspar is used chiefly in glass and ceramics, and hence the demand fluctuates with increasing activity or depression in these industries. In the United States during the last few years about 175,000 tons annually has been mined and ground for those trades alone..

The market for pulverized feldspar is confined largely to well-defined areas in New York, New Jersey, West Virginia, Ohio, and Indiana; the potteries of Trenton, N. J., and in the vicinity of Sebring, Ohio, are the principal centers of use.

Feldspar is generally sold in carload lots. Several large companies both mine and grind their spar, selling the ground product to the potters and other users. Hundreds of smaller producers sell their output of crude spar to the various mills. Some companies market their output through a single broker or selling agency. Amounts less than carload lots usually are handled by brokers and supply houses. The consumption of ground feldspar is practically uniform throughout the year, though irregular fluctuations in demand may occur.

Feldspar is shipped in bulk or in bags. For bulk shipments the car is usually lined with paper, though the pulverized spar may be dumped directly on the car floor. Many shipments are made in burlap bags. The Feldspar Grinders' Institute, Inc., has announced recently the use of waterproof paper bags, designed to hold 100 pounds. The bags are to be billed to the customer at cost and are not returnable. The shipment of feldspar in bags means less loss of spar, less contamination in transportation, and easier handling.

Crude spar is sold on the long ton basis, usually f.o.b. cars shipping point in carload lots.

Ground feldspar is sold on the short ton basis f.o.b. cars at grinding mills.

PRODUCTION CENTERS

The principal deposits of feldspar in the United States are along the Atlantic seaboard, from Maine to Georgia. Feldspar is mined in Maine from Auburn southeast through Brunswick to the coast; in Cheshire and Sullivan Counties, N. H.; in Connecticut from Hartford south and west about 20 miles; in Fulton, St. Lawrence, and Westchester Counties, N. Y.; in Chester County, Pa.; in Carroll, Howard, and Baltimore Counties, Md.; in Bedford and Henry Counties, Va.; and in Mitchell, Avery, and Yancey Counties, N. C. These eastern localities reported 91 per cent of the crude output in 1929. Feldspar is also produced in western United States, the southern part of California being the leading producing center, and the Keystone district of the Black Hills, S. Dak., ranking second. Some feldspar is mined in Mohave County, Ariz., and Boulder County, Colo.

The following charts (figs. 1 and 2) and table 2 show the number of long tons of crude feldspar produced and sold by States, and the total production and value in the United States from 1907 to 1929.

Pennsylvania ranked first among the States in 1907, with a production of approximately 17,500 long tons; however, the production of this State decreased in 1928 to about 2,000 tons and in 1929 to a much lower figure. North Carolina was the largest producer of crude feldspar in 1929, providing approximately 103,200 long tons - about 52 per cent of the total output for the United States.

FOREIGN DEPOSITS

High-grade feldspar occurs in numerous localities in Canada, practically the whole production coming from Ontario and Quebec. Approximately 90 per cent of the Canadian production is exported crude into the United States.

Norway and Sweden are important producers of feldspar, pegmatite dikes being abundant in many sections. Most of the feldspar used by the continental potteries is supplied by the Scandanavian countries.

Other countries producing feldspar in minor quantities are Australia, Belgium, Czechoslovakia, Finland, France, Germany, Italy, Japan, Roumania, Russia, and Union of South Africa.

Table 3 shows world production of feldspar in metric tons from 1916 to 1929. Only the principal producing countries are included.

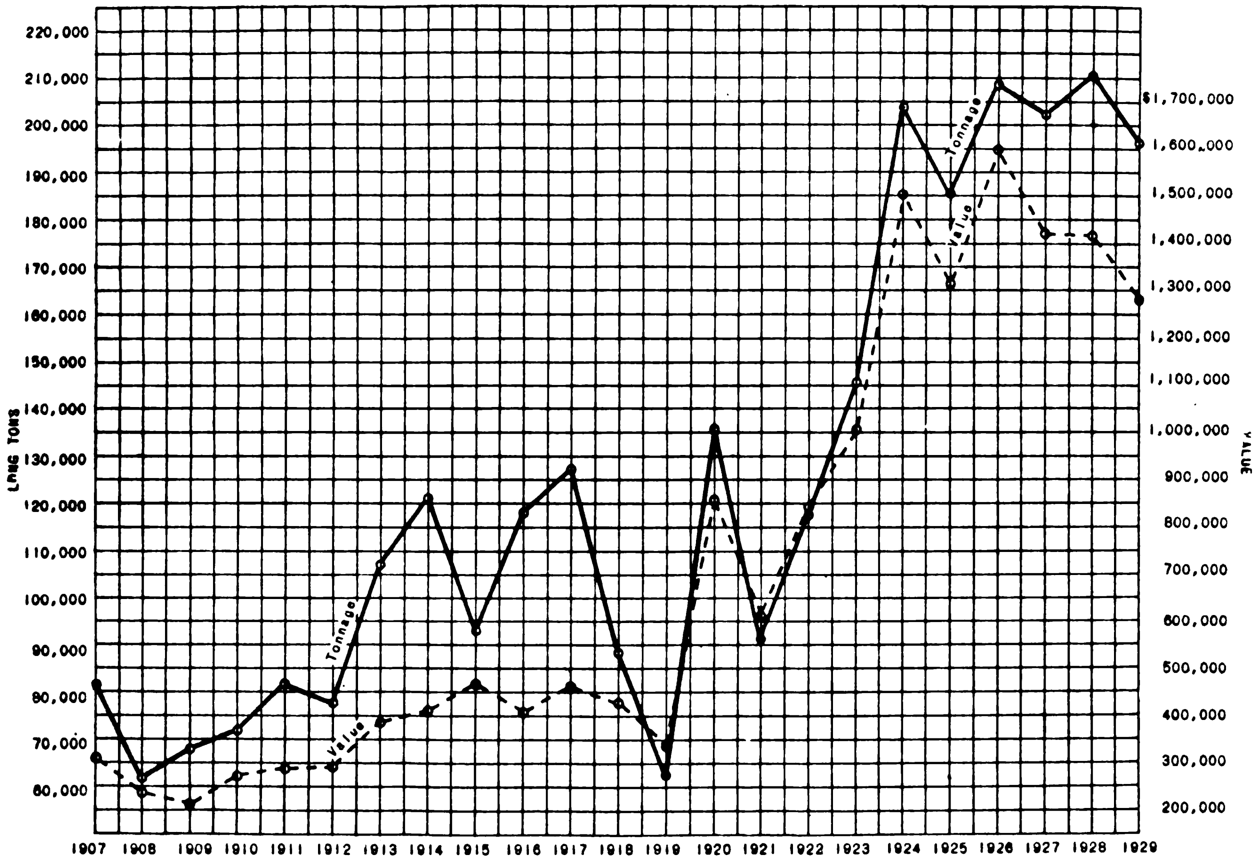

Figure 1.- Total production and value of crude feldspar in the United States, 1907 to 1929

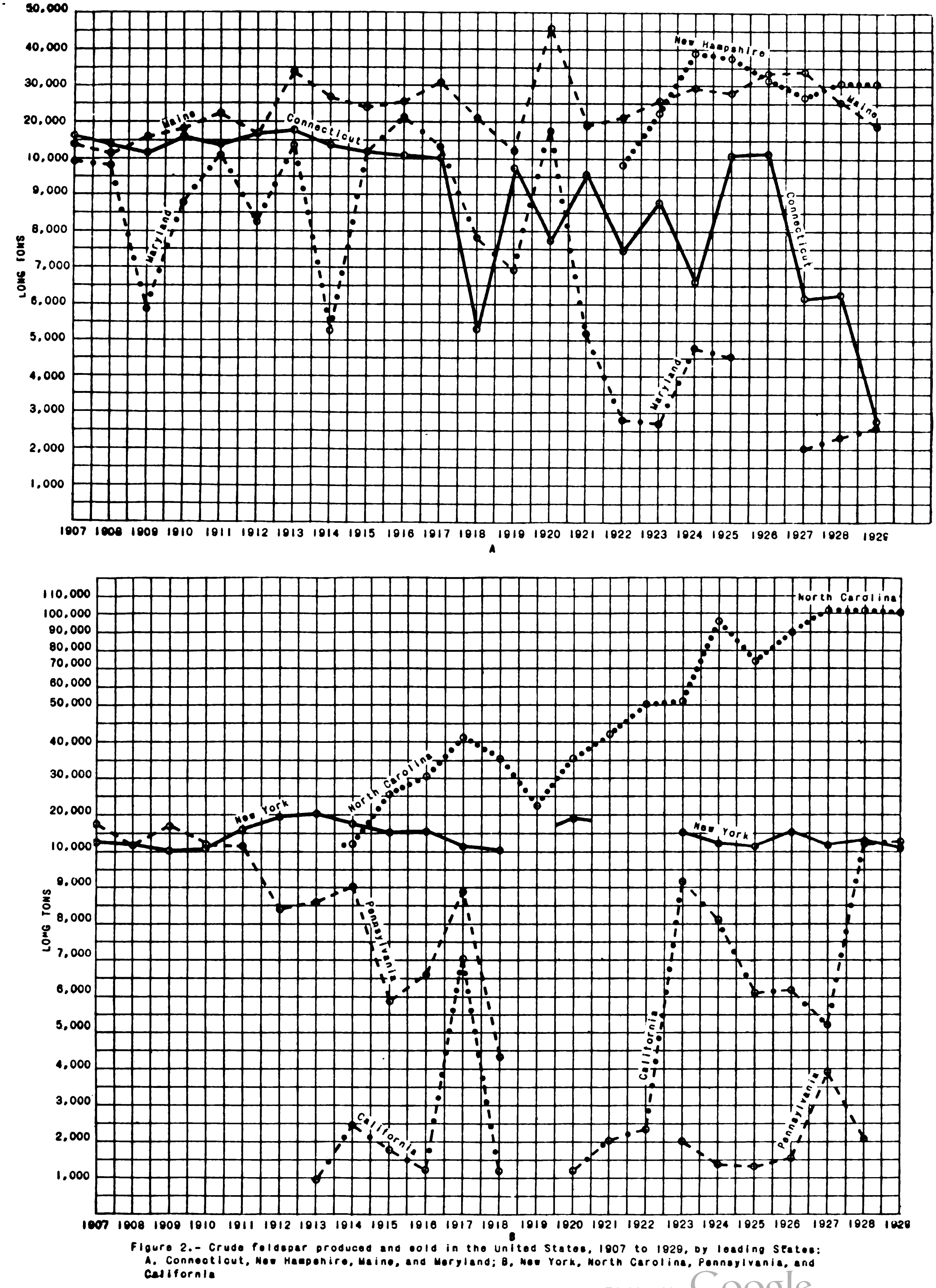

Figure 2.- Crude feldspar produced and sold in the United States, 1907 to 1929, by leading States: A. Connecticut, New Hampshire, Maine, and Maryland; B, New York, North Carolina, Pennsylvania, and California

CRUDE FELDSPAR PRODUCED AND SOLD IN THE UNITED STATES, 1907-1929, BY STATES

(Long tons)

Year	California	Colorado	Connecticut	Maine	Maryland	New Hampshire	New York	North Carolina	Pennsylvania	Virginia	Other States[1]	Total
1907	- - -	- -	17,002	14,708	9,879	- - -	13,758	- - -	17,529	- - -	9,086	81,962
1908	- - -	- -	14,657	12,428	8,691	- - -	13,047	- - -	12,579	(2)	1,521	62,923
1909	(2)	- -	12,182	16,194	5,861	- - -	10,360	- - -	16,583	(2)	7,159	68,339
1910	(2)	- -	16,731	18,538	8,908	- - -	11,082	- - -	13,474	(2)	3,679	72,412
1911	(2)	- -	14,729	23,193	11,334	- - -	16,786	(2)	11,861	(2)	4,865	82,768
1912	(2)	- -	17,031	17,046	8,242	- - -	19,814	(2)	8,438	(2)	6,725	77,296
1913	994	- -	18,114	34,030	14,913	- - -	20,313	(2)	8,597	- - -	11,035	107,996
1914	2,480	- -	14,744	26,842	5,276	(2)	17,481	13,768	9,019	(2)	31,300	120,910
1915	1,789	- -	12,062	24,890	11,147	(2)	15,514	20,635	5,709	(2)	2,107	93,853
1916	1,250	- -	11,012	25,006	21,364	(2)	15,559	30,955	6,555	(2)	6,764	118,465
1917	7,031	- -	10,455	31,720	14,088	- - -	12,019	42,463	8,939	- - -	- - -	126,715
1918	1,296	- -	5,305	22,656	7,843	- - -	11,277	35,732	4,389	- - -	- - -	88,498
1919	(2)	- -	9,715	12,845	6,982	(2)	(2)	22,495	(2)	- - -	11,404	63,441
1920	1,021	- -	7,719	45,352	17,999	(2)	19,294	36,521	(2)	- - -	7,645	135,551
1921	2,057	- -	9,565	18,866	5,155	(2)	(2)	40,712	(2)	- - -	15,510	91,865
1922	2,378	104	7,499	21,692	2,899	14,017	(2)	56,043	(2)	(2)	12,495	117,127
1923	9,297	(2)	8,780	25,029	2,750	23,220	15,161	57,622	2,069	(2)	1,076	145,004
1924	8,027	(2)	6,572	29,912	4,854	39,425	13,839	97,075	1,481	(2)	3,587	204,772
1925	6,077	(2)	10,426	28,404	4,554	38,366	10,474	76,806	1,330	(2)	9,269	185,706
1926	6,271	(2)	11,436	33,897	(2)	33,271	15,517	91,433	1,484	(2)	16,680	209,989
1927	5,260	(2)	6,123	34,328	2,001	27,449	12,020	100,756	3,938	(2)	10,622	202,497
1928	11,391	(2)	6,292	25,063	2,349	30,843	13,971	105,560	2,052	(2)	13,290	210,811
1929	12,770	(2)	2,726	19,992	2,624	30,964	12,696	103,273	(2)	6,677	5,977	197,699

[1] 1907; No record: 1908; Virginia, Minnesota, Wisconsin: 1909; California, Massachusetts, Virginia: 1910; California, Massachusetts, Minnesota, Virginia: 1911; California, Minnesota, North Carolina, Virginia: 1912; California, Minnesota, North Carolina, Virginia, Vermont: 1913; Minnesota, North Carolina, Vermont: 1914; Delaware, New Hampshire, Virginia: 1915; New Hampshire, Virginia: 1916; Georgia, New Hampshire, Vermont, Virginia: 1919; California, New Hampshire, New York, Pennsylvania: 1920; New Hampshire, Pennsylvania: 1921; New Hampshire, New York, Pennsylvania: 1922; New York, Pennsylvania, Virginia: 1923; Arizona, Colorado, Virginia: 1924; Arizona, Colorado, South Dakota, Virginia: 1925; Arizona, Colorado, South Dakota, Virginia: 1926; Arizona, Colorado, South Dakota, Maryland, Virginia: 1927; Arizona, Colorado, South Dakota, Virginia: 1928; Arizona, Colorado, South Dakota, Virginia: 1929; Arizona, Colorado, Pennsylvania, South Dakota.

[2] Included under "Other States."

TABLE 3.-
PRODUCTION OF FELDSPAR BY COUNTRIES, 1916-1929, IN METRIC[1] TONS

Year	Argen-tina	Aus-tralia	Canada	Fin-land	France	Ger-many	Italy	Japan	Norway	Rou-mania	Russia	Sweden	Union of So. Africa	United King-dom	United States
1916	- -	- -	17,679	- -	- - -	2,650	900	- - -	12,311	- - -	- - -	12,724	- -	762	120,366
1917	- -	- -	17,656	- -	- - -	2,530	1,292	- - -	4,435	- - -	- - -	18,533	- -	986	128,749
1918	- -	- -	17,039	- -	- - -	3,772	1,517	- - -	3,488	- - -	- - -	17,850	- -	2,461	39,918
1919	- -	- -	13,316	- -	- - -	6,527	1,100	- - -	5,166	- - -	- - -	12,905	- -	4,734	64,459
1920	- -	4	34,358	55	4,400	5,850	2,600	- - -	6,397	- - -	426	12,049	- -	3,419	137,727
1921	- -	26	27,096	957	4,625	7,249	2,460	- - -	9,348	- - -	673	20,169	- -	1,107	93,339
1922	- -	86	25,153	1,322	2,000	6,030	2,790	16,051	11,833	- - -	685	22,371	- -	843	119,007
1923	- -	33	26,512	639	4,980	8,986	5,070	22,940	13,073	- - -	441	16,857	- -	3,298	147,331
1924	- -	15	40,645	681	5,800	33,139	5,200	23,427	20,875	- - -	3,579	19,309	- -	1,070	208,059
1925	- -	43	26,019	753	3,200	10,258	3,400	19,049	26,735	423	3,613	26,751	- -	- - -	188,687
1926	- -	124	32,614	738	10,550	6,660	5,873	- - -	20,510	1,700	18,640	33,970	101	- - -	213,359
1927	185	109	27,078	553	- - -	7,320	4,054	- - -	27,650	1,943	19,324	30,636	29	- - -	205,747
1928	410	164	28,936	720	- - -	6,230	4,960	- - -	24,075	2,835	- - -	39,921	30	- - -	214,195
1929	(2)	58	33,886	(2)	- - -	(2)	(2)	- - -	26,524	(2)	- - -	(2)	(2)	- - -	200,872

1 A metric ton is 2205 pounds.
2 Data not yet available.

IMPORTS AND EXPORTS

Imports in recent years have constituted somewhat more than 10 per cent of the total domestic supply of feldspar. Almost the entire Canadian production is shipped to this country in crude form and ground in American mills. Import figures have been recorded since 1922 as follows:

Year	Long tons	Value
1923	24,271	$184,924
1924	35,139	284,716
1925	24,994	203,524
1926	29,941	251,896
1927	27,424	206,856
1928	27,857	224,920
1929	29,927	241,852

Small amounts of ground feldspar have been imported, but the quantities are included in imports of unspecified substances, wholly or partly manufactured.

Exports of feldspar are not recorded separately, but are known to be small.

TARIFF

Feldspar was specifically provided for in the tariff acts of 1883, 1890, and 1894. Crude feldspar has been on the free list since 1883. Prior to the latter part of 1922, the duty on ground feldspar was 20 per cent ad valorem, but dating from September 22, 1922, the duty was raised to 30 per cent. The tariff act of 1930 places a duty of $1 per long ton on crude feldspar.

PRICES

In 1929 the average value per long ton of domestic crude feldspar was $6.46, a decrease of 27 cents compared with 1928. The average value of imported crude was $8.08 per long ton in 1929, an increase of 1 cent as compared with the preceding year.

The average price in 1929 per short ton of ground feldspar from domestic crude was $13.73, a decrease of 82 cents compared with 1928, and of $3.11 compared with 1924, the year of highest recorded average. The average value of ground feldspar from imported crude was $20 in 1929, a decrease of 46 cents.

During the past 22 years the value of crude spar has varied considerably, but has shown a gradual increase to a figure nearly double that of the first recorded values. In 1907 the average price per ton for crude spar was $3.67, and in 1929 it was $6.46.

The average price of pulverized spar has also increased considerably, almost doubling during the last 22 years. In 1907 the price per short ton at the mill in carload lots was $7.53, and in 1929 it was $14.30.

Although prices fluctuate considerably from time to time, the following quotations as found in Rock Products, August 2, 1930, page 95, may be of interest.

Soda Feldspar

De Kalb Jct., N. Y.--Color, white; pulverized (bags extra, burlap 2.00 per ton, paper 1.20 per ton); 99% through 140 mesh, 16.00; 99% through 200 mesh, per ton	18.00

Potash Feldspar

Auburn and Topsham, Me.--Color, white, 98% through 140 mesh (bulk)	19.00
Keystone, S. D.--Color, white; analysis, K_2O, 12.30%; Na_2O, 2.28%; SiO_2, 64%; Fe_2O_3, .05%; Al_2O_3, 19.50%, pulverized, 100% through 140 mesh, in bags, 16.00; bulk	15.00
Coatesville, Penn.--Color, white, analysis, K_2O, 12.30%; Na_2O, 2.86%; SiO_2, 66.05%; Fe_2O_3, .08%; Al_2O_3, 18.89%; crude, per ton	8.00
Erwin, Tenn.--White; analysis, K_2O, 10.50%; Na_2O, 2.76%; SiO_2, 67.92%; Fe_2O_3, .07%; Al_2O_3, 18%, pulverized, 99% through 200 mesh, in bags, 16.20; bulk	15.00
Crude, in bags, 8.20; bulk	7.00
Rumney and Cardigan, N. H.--Color, white; analysis, K_2O, 9-12%; Na_2O, trace; SiO_2, 64-67%; Al_2O_3, 17-18%, crude, bulk	7.00-7.50
Rumney Depot, N. H.--Color, white; analysis, K_2O, 8-13%; Na_2O, 1-1½%; SiO_2, 61-68%; Al_2O_3, 17-18%, crude, bulk	7.00-7.50
Spruce Pine, N. C.--Color, white; analysis, K_2O, 10%; Na_2O, 3%; SiO_2, 68%; Fe_2O_3, 0.10%; Al_2O_3, 18%; 99½% through 200 mesh; pulverized, bulk (bags, 15¢ extra)	18.00

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